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June 11, 1959

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ED 178B.

Dear Sir:

This letter report summarizes the research performed under Task Order No. Z during February and March, 1959.

During this period, the new air-film-cooled incinerator was assembled. Experiments were conducted in it as well as with the feeding mechanism attached to the refractory-lined incinerator.

Air-Film-Cooled Incinerator

The design and fabrication of the loading door were completed in line with our discussion on February 2-3. This door has been temporarily installed by clamping it in place, until a suitable hinging device is built. The hinging device will support the door within a movable frame which will hinge on a vertical axis a few inches to the left of the door. By means of an arrangement wherein the door will pivot within the movable frame on a vertical axis midway between the sides of the cover, the hot liner sheet of the door can be kept away from the operator while the frame is swung to the open position. When the door is closed, it will be seated firmly against an asbestos gasket by means of a single latch located on the right side of the incinerator opening.

During final assembly of the unit on February 26, temperature-sensitive paints (Tempilag) representing various melting points up to

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1500 F were applied to small selected areas of the stainless steel liner in order to permit obtaining data on the liner temperature during subsequent test runs. One thermocouple was imbedded in the lower part of the liner where maximum temperatures are expected to occur.

During the first week of March, the unit was moved to a location adjacent to the experimental refractory-lined incinerator and ducting was installed to the blower and to the stack. The first test run was made on March 6, and four test runs were made during the second week of March. Minor changes in louver air and main-jet air were made between runs.

The results of these tests were generally encouraging. The metal-liner temperatures did not exceed 1400 F, and the outside shell remained sufficiently cool to be touched with a bare hand. Maximum instantaneous burning rates up to 370 lb of paper per hr were obtained for periods of up to 10 minutes. However, average burning rates for the first hour of operation on a 250-lb batch of paper were about 225 lb per hr. The maximum burning rates were reached within the first half-hour of operation at the designed air-flow rate of 2,400 std cu ft per min, but the burning rate then declined for the remainder of each test run.

The difficulty in sustaining the higher average burning rates appears to stem from the lack of direct impingement of the main-jet air on the charge of burning paper. From observations of air flow alone in the empty unit, and of the action during the burning of paper, it was evident that the main-jet air was deflected toward the liner by the high swirl velocities obtained from the tangentially directed louver air. The high swirl velocities of the air coming from the tangential inlet duct into the space between the liner and the radiation shield also may have contributed to the deflection and concentration of the air flow near the inside of the liner. Thus, it appeared that the immediate efforts in the development of the new incinerator should be concerned with modifications of the main-air jets in the existing liner and of the pattern of air flow around the liner in order to obtain deeper penetration of the main-jet air into the center of the charge of burning paper and, consequently, to increase the burning rates.

To this end, in the main burning zone below the loading door and still in the circular-cross-sectioned portion of the liner, four nozzles were installed at three horizontal levels. Each nozzle was 1-1/8 in. in ID and 3-1/2 in. long, and was directed toward the central axis of the unit and about 30 degrees downward. Almost the entire length of each nozzle was allowed to project inside the liner, to insure that the main jets of air would not be deflected tangentially by the high swirl velocities which are created by the film-cooling air from the louvers. This arrangement improved the burning rates and promoted fairly uniform consumption of paper across the entire surface of the charge. The inward projecting nozzles showed no tendency to overheat.

Changes in the lower conical zone of the chamber included (1) the addition of four 1-1/8-in. ID nozzles, to increase the burning rate during the closing period of operation, and (2) the elimination of the central inactive zone on the bottom by installing an upright metal cone 18 inches in diameter at the base and 7 inches high that resulted in a circular, V-shaped trough at the very bottom of the combustion chamber. This cone was formed by stacking three sections so as to be separated by 1/16-inch gaps, to provide for film-cooling air to flow downward and outward along the conical surface.

By April 14, when you visited here for the demonstration, 15 test runs had been made. The following is a summary of the experimental results:

(1) Single 200-lb batches of telephone books were burned at an average rate of 200 lb per hr.

(2) Sustained burning rates of 500 lb per hr of telephone books were obtained with intermittent-batch loading of about 12-lb increments. This intermittent loading was done manually without a feeding mechanism; during the 10 to 15 seconds required to feed each batch, the air supply was cut off. At this sustained rate, the stack-gas temperatures exceeded 1600 F for periods of less than 30 seconds immediately following some of the loading periods.

(3) Intermittent-batch feeding is required to reach the higher emergency rates of burning with paper such as telephone books. Smaller amounts of paper fed at more frequent intervals favor higher burning rates. Longer periods of operation would also increase the

average burning rate, because the slower periods of start up and final burnout would then become a relatively small part of total operating time.

(4) The degree of packing of the charge and the kind of paper used influenced the burning rate. Newspapers, which do not pack in so densely as do the pages of telephone books, were burned at average rates of 700 lb per hr in the last test run; instantaneous rates of over 1,000 lb per hr occurring several times during this test gave excessively high gas temperatures of about 2200 F.

(5) At the high burning rates obtained with newspaper, the Type 304 stainless steel grid wire carburized severely and burned away over an appreciable area; this occurred because occasionally some loose paper, which was blown up from the charge, was caught and burned at the grid after many of the loading periods.

(6) The stainless steel air-film-cooled liner reached temperatures slightly over 1500 F at times; but, except for showing moderate warpage, it withstood even the highest of the above-mentioned burning rates satisfactorily.

(7) During the final burnout period, the burning rate decreased gradually and, at the end of operation, there was usually a small residue of unburned paper which had either fallen from the grid or had lost ignition when the last clump in the combustion chamber had broken up.

As we discussed at our meeting on April 14, experimental work will be continued in an attempt to increase the rate of burning during incineration of the last few pounds of paper and to eliminate the unburned residue. Efforts to prolong the life of the grid will also get under way; initially, the present grid will be replaced with one made from Nichrome 5 wire mesh. A blower will be obtained and necessary connections for the field test installation will be fabricated. The device for swinging open the loading door will also be prepared and installed.

Paper-Feeding Mechanism

The modifications which we had discussed in our meeting on February 2-3 were completed on March 2. The mechanism was tested before installation on the experimental refractory-lined incinerator to insure that all of the moving parts functioned properly and to establish the proper procedure for loading, delivery, and withdrawal of the ram.

The mechanism was installed on the incinerator and tested "under fire" on March 5. The ram mechanism performed satisfactorily on the delivery and return stroke. The complete cycle was somewhat slower than in the previous design, but the quantity of paper delivered over a period of time was greater. Two factors contributed to this increase. The first of these was that the mechanism did not jam on the return stroke as it did in the previous design. The second was that better distribution of paper was obtained in the incinerator. Approximately 300 pounds of paper was fed in less than 30 minutes.

The quantity of smoke and fly ash exhausted into the room was approximately 40 per cent less than with the previous design, but was still undesirable. The hinged lid effectively sealed in the smoke and fly ash during the delivery and return stroke. However, the opening beneath the hinged fire door permitted the smoke and fly ash to enter the loading chamber when this lid was opened.

It was then decided that the following modifications of the mechanism should be made in order to improve performance and prevent the smoke and fly ash from entering the loading chamber:

(1) Seal the bottom of the hinged fire door.

(2) Seal the opening around the guide rods at the rear of the loading box.

(3) Install a flapper valve at the rear of the loading box, to allow fresh air to enter on the delivery stroke.

(4) Install a stronger spring on the hinged fire door, to prevent the door from opening when paper is loaded.

(5) Install a scraper at the bottom of the ram to prevent paper from slipping under during the delivery stroke.

These five modifications to the loading mechanism were completed, and the modified mechanism was tested on March 16.

A floating-plate seal, which was installed at the bottom of the hinged fire door, was partially effective at the beginning of the test. As the test progressed, however, the extreme temperature and the debris caused the plate to jam open and the seal became ineffective.

A satisfactory seal was obtained around the guide rods by a plate and bracket assembly which restricted the clearances and also provided additional support for the rods in the retracted position. This assembly was also used to permit fresh air to be drawn into the loading box during the first half of the delivery stroke. This was achieved by increasing the width of the guide rods in the portion corresponding to the last half of the stroke; a 1/8-inch clearance existed in the portion corresponding to the first half of the stroke. Thus, the close-fitting ram draws air in through the clearance.

The stronger spring on the hinged fire door appeared to hold the door closed against any paper which came to rest against the door during loading. The scraper at the bottom of the ram prevented paper from slipping under during the delivery stroke. The ram operated satisfactorily and at no time during the test did it jam either from thermal expansion or from the presence of paper.

The results of this test indicated that the mechanism would be acceptable if the smoke and fly ash could be kept out of the loading area. It appeared that the best way to accomplish this would be to provide an air seal at the bottom of the hinged lid and an air-purging system at the rear of the loading chamber.

The loading mechanism was then modified to incorporate a fire door made from two sheets of steel separated by an air space. An air supply line was arranged to deliver air between the plates to

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form a continuous curtain of air at the bottom of the door. Another air line was attached to the loading chamber to deliver air for purging. Each line contained a gate valve to permit experimental regulation of the air flow from zero to the maximum available.

Two test runs were made late in March to test these modifications. The continuous curtain of air maintained a good seal and the purging system permitted only a very small amount of fly ash to remain in the loading chamber. It is believed that more effective purging can be accomplished if the full cross section of the loading chamber is used in connection with purging.

A layout of a new unit based on the above tests is now under way. This unit will be designed for eventual use on the air-film-cooled-liner incinerator. The refractory-lined-incinerator opening will be modified to fit this unit. It is believed that this approach will result in an experimental feeding mechanism which can be easily transferred to the air-film-cooled unit subsequently.

The total appropriation on this Task Order was $59,470. As of April 1, 1959, the unexpended balance was approximately $5,000.

Sincerely,

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